R 176

~~26.~~ 27 A bioreactor for fermenting solid substrates, comprising a fermentation vessel (2), a charging means for bioreactive substances, and a nozzle arrangement within said fermentation vessel (2) for aeration and thorough mixing of the substrates, wherein the at least one nozzle arrangement (10, 20) has a multitude of pipes (14, 24) extending in parallel into the reaction space (49) of the fermentation vessel (2) and provided with nozzles (16, 28), wherein a first, vertically extending nozzle arrangement (10) can be extended into and retracted from the reaction space (49) of the fermentation vessel (2), characterized by a second, horizontal nozzle arrangement with at least one pipe having nozzle orifices and extending horizontally through the reaction space.

~~27.~~ 28 The bioreactor according to claim ~~26~~ 27, wherein a second, horizontal nozzle arrangement (20) is provided which consists of at least two interconnected pipes (24) extending horizontally and in parallel through the reaction space (49), each having a plurality of nozzle orifices (28).

~~28.~~ 29 The bioreactor according to claim ~~26~~ 27, wherein said horizontal nozzle arrangement (20) can be rotated around a horizontal rotation axis.

~~29.~~ 30 The bioreactor according to claim ~~26~~ 27, wherein said fermentation vessel (2) has a bottom section (32) with a tapering cross-section.

~~30.~~ 31 The bioreactor according to claim ~~29~~ 30, wherein said conically designed bottom section (32) leads into a draining channel (36) which is inclined from horizontal and has a draining valve (40) at the lowest position thereof.

~~31.~~ 32 The bioreactor according to claim ~~26~~ 27, wherein said at least one nozzle arrangement (10, 20) receives compressed gas (48) from a pressure vessel (44, 46).

~~32.~~ 33 The bioreactor according to claim ~~31~~ 32, wherein said pressure vessel (44, 46) contains a bioreactive liquid substance (50) in addition to said compressed gas (48).

~~33.~~ 34 The bioreactor according to claim ~~32~~ 33, wherein said at least one nozzle arrangement (10, 20) alternatively receives compressed air (48) or said liquid bioreactive substance (50) from said pressure vessel (44, 46).

R126

35 ~~34~~. The bioreactor according to claim 27 ~~26~~, wherein said at least one nozzle arrangement (10, 20) can be pressurized with pulsing compressed air (48).

36 ~~35~~. The bioreactor according to claim 27 ~~26~~, wherein said second nozzle arrangement (20) is provided within said fermentation vessel (2) in a height-adjustable manner.

37 ~~36~~. The bioreactor according to claim 33 ~~32~~, wherein a multitude of pressure vessels (52, 54, 56, 58, 60) pressurized with compressed air (48) and connected to a mixing vessel (46) are provided which contain different liquid bioreactive substances.

38 ~~37~~. The bioreactor according to claim 37 ~~36~~, wherein said mixing vessel (46) has a pressure compensating means (47).

39 ~~38~~. The bioreactor according to claim 37 ~~36~~, wherein said pressure vessels (52, 54, 56, 58, 60) are exchangeable and can be separately autoclaved.

40 ~~39~~. The bioreactor according to claim 31 ~~30~~, wherein said draining channel (36) is covered by a wire mesh (38).

41 ~~40~~. The bioreactor according to claim 27 ~~26~~, wherein a pressure lid (8) of said fermentation vessel (2) accommodates said first nozzle arrangement (10) whose pipes (24) extend vertically from the pressure lid (8) into the reaction space (49).

42 ~~41~~. The bioreactor according to claim 41 ~~40~~, wherein said vertical pipes (14) of said first nozzle arrangement (10) are provided in said pressure lid (8) to be exchangeable.

43 ~~42~~. The bioreactor according to claim 27 ~~26~~, wherein said fermentation vessel (2) is connected through a feed line (74) with a measuring chamber (72), which is again connected through a recirculating line (84) with said fermentation vessel (2), and that said measuring chamber (72) can be pressurized for recirculating measured media.

44 ~~43~~. The bioreactor according to claim 27 ~~26~~, wherein a device for heat exchange is provided, especially comprising a device

(i) in which said fermentation vessel (2) has a double wall and the thus formed cavity (51a) can be flowed through with temperature-controlled heat exchange fluids through a

connecting pipe (51b) and discharge pipe (51c); and/or

(ii) which is a horizontal pipe system (20) within said fermentation vessel (2) which can be flowed through with a temperature-controlled heat exchange fluid.

45
~~44~~. A method for the aerobic fermentation of solid substrates, wherein a reaction medium containing such solid substrates is thoroughly mixed by compressed gas (48) supplied to the reaction medium from above.

46 45
~~45~~. The method according to claim ~~44~~, wherein said thorough mixing is effected by a continuous stream of compressed gas or by compressed gas pulses.

47
~~46~~. The method according to claim 44, wherein said solid substances are selected from coal, wood and loaded soils.

48 47
~~47~~. The method according to claim ~~46~~, wherein said solid substance is coal, especially brown coal (lignite).

49 48
~~48~~. The method according to claim ~~47~~, wherein a microorganism suitable for fermentation, nutrients and/or buffers are further added to the reaction mixture.

50 48
~~49~~. The method according to claim ~~47~~, wherein said brown coal or the reaction medium containing said brown coal is tyndallized together with the bioreactor prior to fermentation or prior to the addition of said microorganism.

51 48
~~50~~. The method according to claim ~~47~~, wherein:

(i) said brown coal has a particle size of from 1 to 10 mm;

(ii) said microorganism is selected from molds, yeasts and white rot fungi, especially Trichoderma atroviride;

(iii) the pH of the reaction medium is from 5.5 to 6.0 at the beginning of the reaction;

(iv) the pH is maintained at from 6.5 to 7.2 during the solubilization phase;

(v) the fermentation is performed at a temperature of from 25 °C to 30 °C; and/or

(vi) from 1 to 25 l of compressed air per liter of fermentation broth per day is passed